Muscular hypertrophic adaptations in high and low load training regimes

Eight weeks training intervention

Richard Kalenius
Abstract

Aim
The purpose of this study was to assess muscle hypertrophy outcomes from high and low load strength training routines performed to muscular fatigue in a unilateral design.

Method
14 well-trained men and women (age 26.4 ± 4.4 years, weight 79.9 ± 10.7 kg, height 179.4 ± 76 cm) volunteered to participate in eight weeks of fully supervised training two times per week. Subjects had their legs randomized to a HL protocol performing 3-5 reps and LL protocol performing 20-25 reps. Training was performed in leg press and leg extension and all sets were performed until volitional failure. Subjects were measured for muscle thickness by ultrasound at mid and distal portion of vastus lateralis before and after the study. Paired sample t-test and independent sample t-test was used to establish differences in pre and post and between leg differences.

Results
Muscle thickness increased in HL: MID 8% p = 0.002 and DIST 14% p = 0.009, in LL: MID 7% p = 0.004 and was unchanged at DIST 4% p = 0.512. Total muscle thickness for both measurement sites combined increases significantly in both legs, HL: 9% p = 0.001 and LL: 5% p = 0.045. There were no between leg differences at MID (p = 0.404) or DIST (p = 0.989) after eight weeks.

Conclusion
We conclude that high and low load strength training performed unilaterally to volitional failure yields equal increases in muscle thickness after eight weeks for well-trained men and women.
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Appendix 1 – Subject information
1 Introduction

Increased muscle mass has health and performance benefits for all populations. Studies have reported greater ability to combat type II diabetes (Pesta et al., 2017) and to delay the onset of sarcopenia in elderly (Beaudart et al., 2017). In rodents, well-trained muscles have been shown to cause resistance against depression (Agudelo et al., 2014). Three worldwide epidemiological challenges that all has beneficial effects from physical activity, particularly strength training. Strength training is a common way of increasing muscle mass. From a physiological standpoint, increased muscle mass comes from increased muscle fiber size termed hypertrophy and/or increases in the amount of muscle fibers within a single muscle, termed hyperplasia (Kenney et al., 2015). Hyperplasia has limiting evidence for its existence in human skeletal muscles. However, McCall et al. (1996) showed increased muscle fiber count after 12 weeks of elbow flexor training, suggesting hyperplasia may occur in some individuals. Hypertrophy is regarded as the major morphological adaptation that causes chronic increases in muscle mass and occurs due to added sarcomeres within muscle fibers. The majority of sarcomeres are added in parallel causing an increased muscle fiber diameter (Paul and Rosenthal, 2002). This increase results in greater muscle volume and ultimately, more strength.

The mechanisms responsible for muscle hypertrophy are complex and involve mechanical tension, metabolic stress and muscle damage. Mechanical tension is the tension applied to the mechanoreceptors within the muscles. Higher loads increase the mechanical stretch causing a higher tension in the muscle. This has been shown to effect signaling pathways promoting muscle hypertrophy (Hornberger et al., 2006). Also, different muscles actions stimulate the mechanoreceptors differently and promote different hypertrophic responses. Isometric and concentric actions in a dynamic manner causes sarcomeres to be added in parallel increasing cross-sectional area whereas eccentric actions stretches the muscles and promotes sarcomeres to be added in series (Frey et al., 2009). Metabolic stress is the accumulation of metabolites such as lactate, inorganic phosphate and hydrogen ions (Suga et al., 2012; Teixeira et al., 2017), typically resulting from training regimens with shorter rest intervals and moderate intensity. Also, strength training with low loads with or without restricted blood flow causing high metabolic stress, have shown augmented hypertrophic responses (Barcelos et al., 2015). Lastly, muscle damage occurs mainly from eccentric training and results in mechanical damages in the actin and myosin bridges. This damage has several negative effects including decreased force production, muscle stiffness, swelling and delayed-onset muscle soreness (Tee et al., 2007). However, muscle damage initiates an
inflammatory response increasing satellite cell activity, which ultimately results in myofibers to rebuild and possibly hypertrophy (Hawke and Garry, 2001). Muscle damage apparent with cell swelling is a result of accumulated fluid and plasma proteins. This accumulation causes increases in muscle thickness (Nosaka and Clarkson, 1996).

Several variables are important when planning resistance-training programs. These include training volume, intensity and frequency. Training volume is considered the total amount of work performed, intensity is considered as a percentage of one-repetition maximum (1RM) in a specific exercise and frequency is considered as how many training sessions a muscle group is trained per week (Wernbom et al., 2007). This study focuses on different intensities and how repetition range in an exercise affects muscular hypertrophy.

Knowledge about how different intensities affects muscle growth is important from a performance perspective were muscle hypertrophy in training programs can be optimized and ultimately, affect sport performance. Also, from a health perspective the effect of lower intensities may be applicable for diseased, disabled and elderly individuals.

2 Background

Previous research have investigated effects of different loading schemes between low, moderate and high load in untrained (Mitchell et al., 2012; Assunção et al., 2016; Campos et al., 2002; Holm et al., 2008; Ogasawara et al., 2013), recreationally active (Burd et al., 2010) and trained individuals (Brandenburg and Docherty, 2002; Mangine et al., 2015; Morton et al., 2016; Schoenfeld et al., 2016a; Schoenfeld et al., 2014b; Schoenfeld et al., 2015). Recently, a meta-analysis investigating differences in loading schemes was published (Schoenfeld et al., 2016c). However, due to the limited amount of studies in this field of area, this meta-analysis compared loads lower than 60% 1RM and higher than 65% 1RM. Results showed favorable adaptations from heavier loading schemes and highlights that more specificity is needed to express if even lower and heavier loadings are more favorable for muscle hypertrophy. Since differences in training status has effect on muscle growth, the background section of this paper will focus mainly on the studies examining trained individuals who performed reps until volitional failure.

Morton et al. (2016) compared a full-body workout routine of low loads (20-25 reps) and moderate loads (8-12 reps) at a frequency of two sessions per week. All sets were performed to volitional fatigue. Results showed no differences in muscle cross sectional area of either slow or fast twitch fiber types after 12 weeks of resistance training. Authors conclude comparable effects between the loading schemes when sets are performed to
volitional fatigue. Similar protocol design was used by Schoenfeld et al. (2015) who equated training volume between programs and found no difference in muscle thickness between groups when sets where performed to volitional failure. Brandenburg and Docherty (2002) compared concentric and eccentric type training where loads were adjusted from 1RM in each movement phase. Loading in the eccentric phase corresponded to 110-120% 1RM in the concentric portion of the exercise performed. Thus, results showed no significant differences in muscle hypertrophy even though training volume was similar between groups. Three studies have compared heavy strength training (<5 reps) and traditional hypertrophy type training (8-12 reps). Mangine et al. (2015) found increases in lean arm mass favoring the heavy protocol even though measures of cross sectional area did not reveal differences. However, it is unclear if subjects performed sets until volitional failure. These results are in controversy with the previously mentioned studies and was therefore tested in a training volume equated manner by Schoenfeld et al. (2016a). Results showed favorable increases in muscle hypertrophy from the traditional hypertrophy type training suggesting that volume is important for muscle growth. However, in an earlier study from the same laboratory investigating muscle thickness in forearm musculature, results revealed no difference from either strength -or hypertrophy-type resistance training protocols (Schoenfeld et al., 2014b).

Clearly, optimal loading range has widespread results and assumptions can be made that individual differences likely affect outcomes of muscle growth. No study to our knowledge, have investigated strength training with high load (3-5 reps) and low load (20-25 reps) on muscle hypertrophy. Also, none of the previous studies have examined hypertrophic responses in a unilateral design, which has numerous physiological and statistical benefits (MacInnis et al., 2017).

3 Aim

The purpose of this study was to assess muscle hypertrophy increases from high and low load strength training routines performed to muscular fatigue in a unilateral design. We hypothesized that increases in muscle hypertrophy would have similar increases in both protocols.
4 Method

Total study length corresponded to 11 weeks including testing and training. Eight of these weeks included full training volume and the remaining weeks consisted of testing and a deload phase.

4.1 Subjects

Subjects were recruited from social media and from adds placed in the university. A minimum of two years of lower body strength training experience was required for eligibility to the study. 16 well-trained men and women volunteered to participate in the study, but only 14 subjects (table 1) completed the training program. Subjects disrupted the study due to injuries related to activates outside intervention. Upon the first meeting, subjects completed a wellness questionnaire and signed a written consent. Each subject then had each of their legs randomly assigned to a high-load (HL) and low-load (LL) unilateral training protocol.

Table 1 Subject characteristics. Values are mean ± standard deviation.

<table>
<thead>
<tr>
<th>n</th>
<th>Age, years</th>
<th>26.4 ± 4.4</th>
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<tbody>
<tr>
<td></td>
<td>Weight, kg</td>
<td>79.9 ± 10.7</td>
</tr>
<tr>
<td></td>
<td>Height, cm</td>
<td>179.4 ± 7.6</td>
</tr>
</tbody>
</table>

4.2 Testing procedures

The test procedure involved measurements of length, height and muscle thickness. To avoid elevated blood flow and edema in quadriceps muscles, participants were instructed to refrain from training a minimum of 48h prior testing.

4.2.1 Anthropometric measurements

Length was measured using a stadiometer (SECA, Birmingham, Great Britain) with subjects standing barefoot with their feet together and their back against a wall. Subjects were instructed to stretch as tall as possible without compromising form.

Measurements of weight was performed with a mechanical weight scale (Lindells Vägfabrik, Jönköping, Sweden). Results were noted with one decimal.
4.2.2 Muscle thickness

Changes in muscle hypertrophy was observed and measured using a real time two-dimensional (2D) B-mode ultrasound (Philips Ultrasound, Andover, Massachusetts, USA) with a 40 mm wide probe operating at 11 Hz. Muscle hypertrophy was considered as the muscle thickness (MT) measurements observed with ultrasound. Muscle thickness was defined as the distance between the muscles deep and superficial aponeurosis. The method has been widely used and is considered reliable and valid for muscle hypertrophy measurements (Dupont et al., 2001; Juul-Kristensen et al., 2000; Reeves et al., 2004; Schoenfeld et al., 2016a).

Subjects were instructed to lay supine on a bench with their muscles relaxed while measurements were made on vastus lateralis on both left and right leg. The probe was placed longitudinal with the muscle fibers and a water soluble transmission gel was applied to the probe to optimize ultrasound resolution image. Firstly, the muscle thickness at the muscle belly was measured at 50% of the distance between the lateral epicondyle of femur and the distal portion of trochanter major (MID). This is regarded as a standardized anatomical position for muscle thickness measurements of vastus lateralis (Alegre et al., 2006; Blazevich et al., 2007; Nimphius et al., 2012; Mangine et al., 2015). Secondly, muscle thickness was measured at 22% of the distance from the lateral epicondyle of femur to the distal portion of trochanter major (DIST). Previous studies have reported local differences in muscle hypertrophy response (Wakahara et al., 2012; Wakahara et al., 2013) and therefore, two different muscle thickness measurement sites were used. Sites of measurement was carefully measured using a measuring tape and highlighted with a marker. Minimal pressure was applied to the probe to avoid changes in muscle and adipose tissue.

One image was saved for each anatomical measurement site and all images were saved in six cm scale. Images were analyzed using a third-party software (ImageJ v1.49, National Institutes of Health, Bethesda, MD, USA). Average muscle thickness from three measurements per image was used as results (see figure 1). All muscle thickness measurements were performed in a single-blind manner.
Figure 1 Ultrasound image of *vastus lateralis*. Average distance between deep and superficial aponeurosis of the three measures was used as results for muscle thickness.

**4.3 Experimental design**

The training protocol involved two sessions a week (Mondays and Thursdays) for eight weeks. The training protocol was divided into two training phases with a deload phase in between (see table 2).

The deload phase consisted of one training session during week six. Training was reduced to one set per leg and exercise. Intensity and reps remained unchanged. Before the training program, the leg that started each training phase was randomized. This order was then switched every week to avoid any familiarization effects.
Each training session started with five minutes of cycle ergometer warm-up on self-selected intensity. Warm-up proceeded in leg press machine with increasing intensity following a predetermined protocol (Haff and Dumke, 2012). Only the leg performing the HL protocol warmed up in the strength training machines while the LL protocol skipped the warm-up because it was assumed that the LL protocol performed training at such a low intensity that warm-up wasn’t necessary. Repetitions were performed without a standardized repetition velocity but in a controlled manner at full repetition range. Leg press repetitions was correctly performed when the sled was eccentrically lowered until 90-degree knee angle and concentrically pushed up until full extension. Leg extension repetitions was correctly performed when the resistance was pushed up till a minimum of 160-degree knee angle. On every training session, subjects performed three sets of leg press and three sets of leg extension for both the HL and LL leg. Training was always initiated with leg press followed by leg extension and the legs were trained alternately. Loading was adjusted so that it corresponded to between 3-5 reps for the HL leg and 20-25 repetitions for the LL leg. If subjects performed more or less repetitions than the desired repetition range, load was adjusted in the following set. At baseline, loading corresponded to between 90-95% of one repetition maximum (1RM) for the HL leg and 40-60% of 1RM for the LL leg. Subjects were instructed to perform all sets to volitional fatigue. Due to the mental challenges of performing sets to volitional fatigue, strong verbal encouragement was given before and during each set. Subjects were given two minutes of rest between sets. All training sessions were supervised by individuals experienced with strength training and performed in laboratory settings. Following each training session, subjects were provided a protein solution (Tyngre AB, Johanneshov, Sweden) containing 27g of high-quality whey protein mixed with 300 ml of water. Protein supplementation has been shown to augment muscle hypertrophic response during prolonged resistance training (Cermak et al., 2012).

Subjects were asked to refrain from all other strength training activities of the lower body. Upper body strength training and endurance exercises was allowed during the study. However, increases in endurance exercise volume or intensity was not allowed.
Average training volume was calculated by multiplying reps with load for each session. It was then summed and divided with sessions attended and expressed in kg (Morton et al., 2016; Mangine et al., 2015).

4.4 Statistical analysis

Statistical calculations were performed in SPSS (version 24; Chicago, IL, USA). Paired sample T-test was used as statistical method to evaluate pre and post differences within training regimes and independent sample T-test was used for between leg differences. Results are reported as mean ± standard deviation (SD). Significance level was set at p <0.05.

4.5 Ethics

Subjects was informed of the study purpose, experimental design, procedures and possible risks associated with the study. Participation was handled confidentially and all data was stored only available for study leaders. All subjects signed a written consent regarding all matters. Subjects were also both written and verbally informed that participation was voluntarily and that they could withdraw from completing the study without further questions. Ethics was approved by local review board, Etikprövningsnämnden Stockholm. The trial number was registered as 2016/2159-31.
5 Results

Muscle thickness in the HL leg increased 8% at MID (p = 0.002) and 14% at DIST (p = 0.009) measurement site (figure 2). LL leg increased 7% at MID (p = 0.004) and was unchanged at DIST 4% (p = 0.512) measurement site (figure 3).

Total muscle thickness for both MID and DIST combined increased significantly in HL 3.958 ± 0.58 to 4.361 ± 0.76 cm which corresponded to 9% (p <0.001) and in LL 3.733 ± 0.56 to 3.945 ± 0.64 cm which corresponded to 5% (p = 0.045). No between leg difference was observed for any of the measurements.

![Figure 2](image)

Figure 2 Muscle thickness at MID measurement site for high-load (HL) and low-load (LL) leg in vastus lateralis ± SD. * indicates significant increase between PRE and POST.

Average training volume for HL leg was 2671 ± 678 kg and for LL leg 9289 ± 2830 kg (p <0.001). Average training volume for each exercise was also significantly different between legs. Leg press training volume for HL leg was 1937 ± 553 and LL leg 7615 ± 2501 kg (p <0.001). Leg extension training volume for HL leg was 798 ± 210 and LL leg 1893 ± 458 kg (p <0.001).

Session attendance was excellent at an average of 95.8%, ranging between 14-17 sessions throughout the training program. Some subjects refrained from exercise sessions due to sickness and soreness.
Figure 3 Muscle thickness at DIST measurement site for high-load (HL) and low-load (LL) leg in vastus lateralis ± SD. * indicates significant increase between PRE and POST.
6 Discussion

The main findings of this study was that muscle hypertrophic response measured as muscle thickness increased similarly between high and low load strength training protocols in a unilateral design, even though there was a large difference in training volume (2671 ± 678 kg vs. 9289 ± 2830 kg). The HL protocol increased MT by 8% and LL with 7% at MID measurement site. Further, HL increased MT by 14% and LL increased insignificantly by 4% at DIST measurement site.

Our results together with previous studies, show that repetition ranges from 2-35 with intensities ranging from approximately 30-95% 1RM seems to yield equal responses on muscle growth in lower body for resistance trained subjects as long as training is performed until volitional failure (Brandenburg and Docherty, 2002; Mangine et al., 2015; Morton et al., 2016; Schoenfeld et al., 2015; Schoenfeld et al., 2014b). To our knowledge, only one study showed preferable adaptations on muscle growth for lower body musculature favoring a higher volume format when sets are performed until volitional failure (Schoenfeld et al., 2016a). Schoenfeld et al. (2016a) showed significant advantages from hypertrophy-type training (8-12 reps) compared to heavy strength training (2-4 reps) on MT measurements on lateral thigh. Authors suggest that the doubled training volume in the hypertrophic-type protocol likely is the cause for the significant difference in MT. The same authors have previously reported that training volume is an important factor for muscle growth (Schoenfeld et al., 2016b). However, in the present study training volume per session was more than threefold in the LL compared to the HL protocol (HL: 2671 ± 678 kg compared to LL: 9289 ± 2830 kg) and yet, MT increases were similar. This suggests that there is a roof for maximal training volume and also that increases in muscle hypertrophic response is not determined by intensity or training volume alone, but rather together with other training variables.

Mangenie et al. (2015) found significant differences in lean arm mass favoring high loads, but found no differences in lateral thigh. Authors speculate that eight weeks of supervised training was not sufficient to reveal differences in lower body musculature between loading protocols. This is based on studies by Chen et al. (2011) who showed that lower body musculature is more resistant to muscle damage than upper body musculature, and Abe et al. (2000) who showed that increases in muscle thickness occurs earlier in upper body compared to lower body musculature. It is believed that daily usage of lower limbs is the major cause for the longer adaptation time. With this in mind, the intervention period in the present study might have been too short to detect a potential difference between HL and LL training.
The present study supports previous studies showing that the hypertrophic response does not seem to be intensity dependent when training is performed to volitional failure. A possible explanation for this could be that high-threshold motor units are recruited in the end of a failure reaching set even when a low load is used. This might then activate a large spectra of motor units and thus engage muscle fibers resulting in similar muscle hypertrophy between different loading zones (Spiering et al., 2008). However, high load protocols have been shown to increase EMG-activation to a larger extent compared to low load protocols even though reps are performed until volitional failure (Jenkins et al., 2015; Looney et al., 2016; Schoenfeld et al., 2014a). Muscle fiber activation seems to be contributor but not the explanation to hypertrophic responses. Jenkins et al. (2015) revealed greater muscle hypertrophic response in the low load protocol even though EMG-activation was higher in the HL protocol. This suggests that other physiological responses are the main drive for muscle hypertrophy.

Performing sets to muscular fatigue seems to be a major contributor to muscle hypertrophy. Willardson et al. (2010) writes that performing sets to muscular fatigue is associated with increased levels of lactate and growth hormone secretion, suggesting an anabolic state. Authors also mention that different physiological responses are seen between high and moderate loading protocols causing higher metabolic stress and growth hormone secretion from moderate loadings and therefor suggests favorable adaptations for muscle hypertrophy. This has been opposed by Morton et al. (2016) who measured acute hormone concentrations between moderate and low load protocols and found no differences between protocols, suggesting that acute hormonal levels are not the contributor to possible difference in hypertrophy outcome between moderate and low loading zones. No study to our knowledge have directly compared hormonal differences from high and low load in resistance training protocols and it might therefore be differences between the HL and LL protocols in the present study. Unfortunately, we did not take any blood samples and could therefore not examine the effect of training on hormone concentrations.

**6.1 Method discussion**

We adopted a unilateral study design which have been shown to have numerous advantages. MacInnis et al. (2017) reports that unilateral designs have no transfer effects of citrate synthase, 3-hydroxyacyl-CoA dehydrogenase, succinate dehydrogenase maximal activities, muscle capillarization, local hemodynamics, metabolic adaptations during submaximal exercise, skeletal muscle protein synthesis and hypertrophy between legs. Wilkinson et al. (2006) reported local hypertrophic responses from unilateral training with no increases in
cross sectional area of the untrained leg suggesting that unilateral training models are suitable for comparing differences in hypertrophy between loading protocols. Also, the benefits of unilateral designs are that differences in nutrition, sleep and other activities are equalized between training protocols. From a statistical standpoint, amount if subjects needed for statistical power are greatly reduced in unilateral training designs.

6.2 Limitations

Some limitations are worth concern before attempting to draw conclusion from these results. Subjects were advised to maintain their normal dieting behavior throughout the study but no nutritional reports were used. Therefore, we cannot out rule differences in energy intake between subjects that may affect hypertrophic outcomes. However, we attempted to assure adequate protein intake was achieved by supplying protein immediately after all training sessions. Another limitation was additional training stimuli from aerobic or team sport exercises. Here we asked subjects to maintain their aerobic or team sport exercise volume throughout the study. Increases in training stimuli from training outside the study sessions were not encouraged and strength training exercises involving legs were strictly avoided. Two subjects were involved in team sports such as handball and football. Possible fatigue may have affected performance during study training sessions but were not observed or mentioned. Also, training status between individuals were widespread. Inclusion criteria were minimum two years of strength training experience but measurements of 1RM strength revealed ranges between 46.7-87.1 kg in leg extension at baseline. Different baseline strength may affect hypertrophic responses of individuals and have been reported elsewhere (Divljak, 2017).

7 Conclusion

We conclude that high and low load strength training performed unilaterally to volitional failure yields equal increases in muscle thickness after eight weeks for well-trained men and women.
8 References


Appendix 1

Information till försökspersoner:

Projekttitel:
Muskulära effekter av tung respektive lätt styrketräning.

Ansvariga:
Forskningshuvudman: Gymnastik- och idrottshögskolan (GIH).
Student: Gordan Divljak, 0706 170777, gordan.divljak@student.gih.se
Student: Richard Kalenius, 0706 892060, richard.kalenius@student.gih.se
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Plats för undersökningen: GIH, Lidingövägen 1, 114 86 Stockholm

Bakgrund/syfte:

Vetenskapliga frågeställningar:
1. Hur påverkas hypertrofi, styrka och kraftutveckling i lårmuskulaturen till följd av tung respektive lätt styrketräning?
2. Hur påverkas hypertrofi, styrka och kraftutveckling i typ 1 respektive typ 2 muskelfibrer till följd av tung respektive lätt styrketräning?

Metod:
Under åtta veckor ska vältränade män och kvinnor utföra styrketräning under kontrollerade former på Gymnastik & Idrottshögskolan, GIH. Ena benet tränas med en hög belastning (ca 90% av max) och andra benet med en lättare belastning (ca 30% av max) där varje set utförs till utmattning. Träningen består av två övningar; unilateral (utförs med ett ben) benpress och unilateral benspark som anses tekniskt enkla och säkra att utföra. Före och efter träningsperioden utförs styrkemätningar och lårmuskulaturens storlek bedöms med hjälp av
ultraljud. Utöver detta tas muskelprover (biopsier) både före och efter träningsperioden för att kunna studera effekterna på muskelfibernivå.

Vad är en biopsi?

Kunskapsvinster:
Det är viktigt att förstå hur olika typer av träning påverkar muskeltillväxten så att den kan optimeras hos både idrottare, motionärer och patienter. Äldre och sjuka som inte kan träna med tung belastning kan ha nytta av att träna på lätt belastning som kan generera hypertrofi och ökad muskelstyrka. Från ett rehabiliteringsperspektiv kan detta ge förståelse för hur träningsrespons kan ske även på lätt belastning. Ur idrottsperspektiv kan detta ge förståelse för hur muskeltillväxt och styrka ska maximeras i syfte att öka prestationsförmågan.

Hur går studien till?
Studien är uppdelad i flera delmoment:

1. Första steget är att via telefonmöte informera och intervjuar dig kring projektet. Anledningen till intervjun är att vi vill ha information angående din hälsa och träningsbakgrund för att du skall kunna inkluderas i studien.

2. Vid nästa delmoment kommer du att få fylla i en hälsoenkät, därefter mäter vi din maximala styrka i benpress och benspark. Vid ett separat tillfälle kommer vi även att ta muskelprov från yttre sidan av lårmuskeln på vardera ben, samt mäta muskeljocklek i framsida lår med hjälp av ultraljud.

3. Efter dessa förberedande tester kommer du att genomföra styrketräningspass två gånger/vecka i 8 veckor. Träningen kommer att bestå av unilateral benpress och benspark där ena benet tränas med tung belastning och andra benet med lätt belastning. Träningen kommer utföras på måndagar och torsdagar på GIH, varje pass tar ca 30 min.

4. Efter träningsperioden upprepas samtliga tester och prover som utfördes före träningen.
Vilka är riskerna?
Muskelbiopsi innebär att en liten bit muskelvävnad (0,05-0,10 gram) tas ut med en specialnål. Ett 4-5 mm långt snitt görs genom huden, genom vilket biopsinålen förs in och ett muskelprov tas ut. Själva ingreppet med biopsinålen är över på ett par sekunder. I allmänhet känns en muskelbiopsi som ett trubbigt slag mot benet. I vissa fall kan en skarpare smärta kännetecknas, som går över så fort nålen tas ut. För att förhindra blodutgjutning i muskeln lägger vi ett lokalt tryckförband över biopsistället, som skall vara kvar under 1-2 timmar. Liksom vid alla hudsnitt kan en hudnerv skäras av med lokalt känselbortfall i huden som följd. Vid den här typen av biopsi är denna komplikation mycket ovanlig. I de fåtal fall där denna komplikation har ägt rum har allt normaliserats efter 6-12 månader.


Biobanksprover/hantering av data/sekretess:
Försäkring/ersättning:
Personskadeskyddsförsäkring tecknad av GIH gäller under studien. Ersättning per biopsitillfälle utgår med 500 kr (före skatt). Detta medför en total ersättning på 4x500 = 2000 kr om du deltar i hela studien.